

# Prevalence of Sleep-disordered Breathing and its Association with Obesity among Saudi Schoolchildren

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## ABSTRACT

**Aim and objective:** Epidemiological studies of sleep disturbances are essential to promote awareness among families and educational officials and deliver appropriate treatment at a very early timing. The aim of this population-based study was to determine the frequency of sleep-disordered breathing (SDB) symptoms and its association with obesity among schoolchildren in West Saudi Arabia.

**Materials and methods:** This cross-sectional study comprised 2,000 schoolchildren aged 6–12 years. Sleep-disordered breathing symptoms were assessed with Arabic version of Pediatric Sleep Questionnaire (PSQ). Overweight/obesity was evaluated using body mass index (BMI) and their association with SDB was tested using a regression analysis model.

**Results:** Overall, 23% of children were at high risk of SDB. Prevalence of habitual snoring was 15.9% and sleep apnea 4%. Boys were at higher risk of SDB than girls ( $p = 0.026$ ), while age had no effect ( $p = 0.254$ ). High-risk SDB had a strong association with sleep symptoms compared to low-risk SDB ( $p < 0.05$ ). Sleep-disordered breathing increased significantly in overweight and obese children ( $p = 0.017$  and  $p < 0.001$ , respectively).

**Conclusion:** Around 23% Saudi schoolchildren are at risk of SDB. Related symptoms were strongly associated with high risk of SDB. Overweight and obesity had a strong and progressive association with SDB.

**Clinical significance:** The results will help in identifying children at high risk of developing SDB and plan for early intervention to avoid the progression of SDB later in life.

**Keywords:** Obesity, Pediatric sleep questionnaire, Sleep-disordered breathing.

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## INTRODUCTION

Sleep disturbances can burden normal development during childhood. Children who are sleep deprived often demonstrate daytime fatigue, restlessness, hyperactivity, and poor schooling performance.<sup>1–4</sup> In severe cases, sleep pathology carries devastating health consequences resulting in hypertension, heart diseases, insulin resistance, and other metabolic disturbances.<sup>5,6</sup> Sleep-disordered breathings (SDBs) have a very large scale of symptoms, from plain primary snoring which might be harmless to children to obstructive sleep apnea syndrome (OSAS) where sleep is severely disrupted by periods of respiratory obstruction and hypopnea with life-threatening consequences. Commonly, adenotonsillar hypertrophy is the major cause of SDB in children. However, the etiology of this condition is multifactorial. Possible risk factors include obesity, allergy, sex, ethnicity, exposure to cigarette smoke, low-socioeconomic status, and family history of snoring or obstructive sleep apnea (OSA).<sup>7–9</sup>

Reaching an accurate diagnosis and deciding on the proper treatment is one of the most common management challenges for sleep clinicians. Mild and moderate cases of SDB can be managed with conservative approaches. However, in severe cases (OSA), these are more likely to be ineffective where surgery is usually provided as the definitive line of treatment.

An overnight, attended, in-laboratory polysomnogram (PSG) is the gold standard for diagnosing sleep disturbances in children.<sup>10</sup> It is a noninvasive procedure, recording several physiological measurements, such as the sleep stages and the respiratory functions. However, sleep labs and qualified physicians are limited. Moreover, PSG is costly and remains prohibitively expensive for universal use in all children.<sup>11</sup> Sleep questionnaires are the most basic screening tool to recognize the symptoms of snoring and

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other sleep problems in children. These are inexpensive and suitable for epidemiological and community-based studies.

Habitual snoring (HS) is the cardinal symptom of SDB in children. In a large cohort of school-aged children in Australia, HS was found in 10%.<sup>12</sup> The prevalence of HS among Turkish children aged 6–13 years was 7%.<sup>13</sup> In USA, 3.7% of children were diagnosed with a sleep disorder in a very large population sample.<sup>14</sup> Ethnic and racial variations may influence the prevalence of SDB.<sup>15,16</sup> However, significant differences among epidemiological studies may suggest that sleep disorders are underdiagnosed particularly in the primary care networks.

The epidemic growth of pediatric obesity is a major public health concern with significant comorbidities particularly metabolic, cardiovascular, and sleep-related breathing disorders. Obesity and SDB appear to contribute to the initiation and

progression of each other. However, underlying mechanisms and factors predisposing to the higher risk of SDB among obese children are not fully understood. In Saudi Arabia, prevalence of pediatric obesity has risen alarmingly over the past decade. In a recent study, 18.2% of Saudi children aged 6–16 years were obese (18% for girls and 18.4% for boys) with the rate doubled over a 10 year period.<sup>17</sup>

Despite the exponential increase in research on SDB from the years 2000 and above, population-based data about SDB in children are still lacking. The aim of this study was to determine the prevalence of SDB and its association with obesity among Saudi primary schoolchildren.

## MATERIALS AND METHODS

This cross-sectional study was approved by the Research and Ethics Committee of the Health Campus in Universiti Sains Malaysia and the regional directorate of education. The study was conducted between May and June 2019 in Madinah, West Saudi Arabia with an area of 600 km<sup>2</sup>, and 1.35 million of population according to a recent statistics.<sup>18</sup>

To ensure that sample is representative of schools in Madinah District in terms of gender distribution and socioeconomic status, 22 primary schools (half males and half females) were randomly selected from the national registry database in Madina District. A total of 2,000 boys and girls aged 6–12 years received sleep questionnaires evenly. Later on, two age groups were identified within the sample (6–9 and 10–12 years). Those children who had their tonsils removed were excluded from the study. History of orthodontic treatment or extraction of permanent teeth was excluded.

The Arabic version of Pediatric Sleep Questionnaire (PSQ) was used to evaluate sleep-related problems. For this purpose, forward-backward translation method was followed as recommended by the World Health Organization.<sup>19</sup> The PSQ was first described and validated in 2000 by Chervin et al.<sup>20</sup> It consists of 22-item parent-reported questionnaire and composed of four subscales for SDB, snoring, sleepiness, and behavior. Responses are “yes” = 1, “no” = 0, and “don’t know” = missing. The mean response on non-missing items is the score, which can vary from 0 to 1. Scores >0.33 (≥8) are suggestive of high risk for a pediatric sleep-related breathing disorder, whereas children with fewer than 33% (<8) positive responses are considered as having low risk of SDB. Within the PSQ, habitual snorers refer to those who snore all the time and always snore during sleep, while sleep apnea represents stoppage of breathing during sleep. In their systematic review, De Luca Canto et al.<sup>21</sup> concluded that only the PSQ had enough diagnostic accuracy to warrant its use as a screening method for pediatric SDB.

Each student received an envelope containing a letter explaining the aims of the study, an informed consent form, and the sleep questionnaire to be filled in by their parents who were asked to follow their children’s sleep for 2 weeks before scoring to ensure response accuracy. The parental consent form was simple with short sentences suitable for parents of potential participants and showed the benefits associated with the research and their children rights as a research subject. Moreover, height and weight measurements were obtained for each student. Body mass index (BMI) was calculated using a standard formula: weight/height<sup>2</sup> (kg/m<sup>2</sup>). Body mass index percentile value for each patient was calculated using gender/age-specific growth charts described by Centers for Disease Control as follows: underweight, BMI less than 5th percentile; normal, 5th percentile to less than 85th percentile;

overweight, 85th percentile to less than 95th percentile; and obese, 95th percentile or greater.

## Statistical Analysis

Statistical Package for the Social Science version 22 (IBM SPSS Statistics for Windows, Version 22.0; IBM, Armonk, New York, USA) was used to perform all statistical analyzes. Chi-square tests were used to detect differences among low- and high-risk SDB children in terms of age, sex, snoring, mouth breathing, sleep apnea, and obesity represented by BMI. A logistic regression model was used to determine association of SDB with gender, age, sleep symptoms, and obesity. For this purpose, univariate analysis and multivariate regression were performed. Results were given as odds ratios (ORs) with 95% confidence intervals (95% CIs) and significance were considered at *p* values <0.05.

## RESULTS

The children’s mean age enrolled in this study was 9.7 ± 1.4 years. Response rate to PSQ was 79% (1,580 out of 2,000); 842 boys (53.3%) and 738 girls (46.7%). Another 52 questionnaires (2.6%) were excluded from further analyzes due to missing information or incomplete scoring.

The results of PSQ scoring (frequency and percentage) are presented in Table 1. Overall, 352 (23%) of children were at high risk of SDB (≥8 “yes” responses on scale). Prevalence of habitual snoring was 15.9% and sleep apnea 4% within the sample. Table 2 shows the correlation between sleep symptoms and the risk of SDB. Males had higher risk of developing SDB compared to females (*p* = 0.026), while age had no effect (*p* = 0.254). High-risk SDB had a strong association with sleep symptoms compared to low-risk SDB (*p* < 0.05). In this study, 17.2% of the children had overweight/obesity. High-risk SDB increased significantly in overweight and obese children (*p* = 0.017 and *p* < 0.001, respectively).

Regression analysis for possible risk factors associated with SDB is shown in Table 3. Subjects with baseline snoring, sleep apnea, and mouth breathing were at a four times higher risk of developing SDB. Boys had higher risk of developing SDB compared to girls (OR: 1.79, 95% CI: 0.92–2.49). Overweight and obesity had a strong and progressive association with SDB at both univariate and multivariate levels. Overweight children were four times as likely to develop SDB as those with normal BMI (OR: 4.32, 95% CI: 2.23–6.43), while obese children were at almost five times higher risk of developing SDB as those with normal BMI (OR: 4.94, 95% CI: 2.51–6.78).

## DISCUSSION

Early screening of SDB and identification of its prevalence in children are important so that appropriate treatment can be delivered to avoid adverse health outcomes. In addition, there is a 226% (2.3-fold) increase in healthcare utilization among children with OSA when compared with unaffected individuals. Hence, early diagnosis and intervention would be beneficial and cost-effective.<sup>22</sup> In this study, the PSQ was used as a potential screening tool to determine the prevalence of SDB symptoms among Saudi primary schoolchildren aged 6–12 years in Madina, West Saudi Arabia. This is the first time that the impact of the variability of BMI on sleep schedules is explored among Saudi schoolchildren. The return rate of the sleep questionnaires was 79% addressing good parent/child cooperation which was essential for the success of the study. This is may be due to the point that these questionnaires were provided

at the very start of assessment when subject compliance is likely to be at a premium. Moreover, screening within densely populated areas (as in our study) rather than provinces might play a role in this good response. Chervin et al. showed that both sensitivity and specificity of the PSQ were high when 8 or more positive answers to

the 22 question items were considered abnormal. They proposed an optimal SDB scale cutoff of 0.33 with greater values suggesting SDB diagnosis. These criteria resulted in a scale sensitivity of 0.85 and specificity of 0.87.<sup>19</sup>

Sleep discrepancies among Saudi schoolchildren were described for the first time by BaHammam et al., 2006, and found to be a prevalent dilemma.<sup>23</sup> In this study, 23% of children were at high risk for SDB. This level compares unfavorably to several similar reports. Wang et al., 2013, found that 12.1% of Chinese schoolchildren aged 6–14 years had SDB.<sup>24</sup> Lower rates were reported in Greek (6.9%) and German (10.1%) schoolchildren.<sup>25,26</sup> Reported habitual snoring among Saudi schoolchildren (15.9%) was higher than that for British (7.9%)<sup>27</sup> and Chinese (7.2%)<sup>28</sup> but less than that for Brazilian schoolchildren (27.6%).<sup>29</sup> This wide range may be attributed to various methods of sampling, different age groups, and cultural factors. Moreover, there is no consensus about clear definition of HS. In this study, sleep apnea was present in 4% within the sample. In comparison, this is higher than that scored among Italian (1%)<sup>30</sup> and Brazilian children (0.8%).<sup>29</sup>

Boys had higher risk of developing SDB compared to girls ( $p = 0.026$ ). Majority of questionnaire-based studies show boys to have more SDB compared with girls.<sup>31,32</sup> Male predilection as a risk factor of SDB is a common finding in most sleep publications, but the etiology responsible for this predilection is still unclear. Some have suggested that hormonal differences and/or body fat distribution among both genders may have a role.<sup>33,34</sup>

This study demonstrated a significant association between overweight/obesity, as measured by the BMI, with SDB ( $p = 0.017$  and  $p < 0.001$ , respectively). Obesity and its implications in the development of SDB have been widely recognized by the mainstream sleep research creating a bidirectional relationship where SDB can also exacerbate obesity and related metabolic physiology. Redline et al., 1999, found that obesity was an important risk factors for SDB in children and adolescents with less effect in children where ventilatory control mechanisms are more efficient.<sup>15</sup> Adiposity, an aspect of obesity, has been reported as an important risk factor for developing SDB in children.<sup>35,36</sup> Both visceral fat and adipose tissue under the chin was associated with a higher risk of developing SDB by mass loading of upper airway and respiratory muscles altering their structure and function.<sup>32</sup> In fact, the contributing mechanisms of obesity in the development of SDB is an active area of debate. Some authors have proposed that the increased fat mass deposits specifically those in the tongue and

**Table 1:** Prevalence of SDB-related symptoms stratified by PSQ

PSQ domain	Question	n (%)
Snoring	Snores all the time during	65 (4.3)
	Always snores during sleep	178 (11.6)
	Snores loudly	162 (10.6)
	Snores during day	141 (9.2)
SDB	Difficulty in breathing	151 (9.9)
	Has stopped breathing during sleep	61 (4.0)
	Mouth breathing during day	301 (19.7)
	Dry mouth upon waking	361 (23.6)
Daytime sleepiness and development	Wets bed, walks during sleep, or wakes up scared during night	223 (14.6)
	Wakes up unrefreshed	395 (25.9)
	Wakes up with headache	133 (8.7)
	Difficult to wake child up	316 (20.7)
Inattention/hyperactivity	Sleepiness during the day	257 (16.8)
	Sleepiness during the day noticed by teacher	141 (9.2)
	Has stopped growing at a normal rate	31 (2.0)
	Overweight	189 (12.4)
Number of children at high risk of SDB (≥8 yes responses)	Does not respond quickly when spoken to	169 (11.1)
	Difficulty in organizing and managing tasks	242 (15.8)
	Easily distracted by external stimuli	435 (28.5)
	Seems restless and moves when seated	391 (25.9)
	Looks in a hurry all the time	411 (26.9)
	Interrupts others during speech	366 (24.0)
		352 (23%)

PSQ, pediatric sleep questionnaire; SDB, sleep disordered breathing

**Table 2:** Children characteristics and related demographic features according to risk of SDB

Variable		All children (N = 1,528) n (%)	Low-risk (N = 1,176) n (%)	High-risk (N = 352) n (%)	p value	ORs
Age	6–9 years	696 (45.6)	601	182	0.254	1.56 (0.96–3.66)
	10–12 years	832 (54.4)	575	170		
Sex	Male	756 (49.5)	563	193	0.026	1.91 (1.03–4.13)
	Female	772 (50.5)	651	121		
Snoring		243 (15.9)	82	162	<0.001	1.36 (0.82–2.88)
Sleep apnea		61 (4.0)	19	42	<0.001	1.76 (1.12–3.32)
Mouth breathing		301 (19.7)	132	169	0.014	1.33 (0.79–2.49)
BMI	<5th percentile	168 (11)	85	83	0.45	1.82 (1.09–3.56)
	5th–75th percentile	1098 (71.8)	531	567	0.13	1.23 (0.94–3.02)
	75th–90th percentile	189 (12.4)	63	126	0.017	2.01 (1.26–4.57)
	>90th percentile	73 (4.8)	13	60	<0.001	2.31 (1.69–4.76)

BMI, body mass index; ORs, odds ratios; SDB, sleep disordered breathing. Significant at  $p < 0.05$ .



**Table 3:** Logistic regression analyzes of SDB risk

Variable	Univariate analysis			Multivariate analysis				
	Odds ratio	95% Confidence interval	p value	Odds ratio	95% Confidence interval	p value		
Age	1.26	0.68	1.54	0.231	1.13	0.73	1.39	0.268
Sex	1.79	0.92	2.49	0.023	1.84	0.95	2.61	0.027
Snoring	3.96	1.95	5.46	0.008	3.79	2.03	4.14	0.012
Sleep apnea	4.31	2.31	6.37	<0.001	4.48	2.45	5.91	<0.001
Mouth breathing	3.88	1.95	5.86	<0.001	3.93	1.97	5.74	<0.001
BMI								
<5th percentile	1.23	0.76	1.44	0.421	1.29	0.81	1.53	0.351
5th–75th percentile	1.17	1.86	5.21	0.124	1.22	0.85	1.39	0.162
75th–90th percentile	4.32	2.23	6.43	0.006	4.41	2.38	6.27	0.009
>90th percentile	4.94	2.51	6.78	<0.001	4.89	2.61	6.64	<0.001

BMI, body mass index; SDB, sleep disordered breathing. Significant at  $p < 0.05$ .

pharyngeal tissues will reduce normal muscular tone experienced during rapid-eye movement (REM) which may result in mechanical restriction of airflow.<sup>37,38</sup> Moreover, lung mechanics, functional residual capacity, and tidal volume may be affected by the increased physical mass. However, these mechanisms do not explain why only a subset of obese individuals and lean individuals develop SDB. Therefore, another trend was directed toward obese physiology rather than physical weight as an underlying mechanism of SDB. Impaired glycemic control, insulin resistance, and altered leptin levels are crucial physiological components of obesity. Increased autonomic response and histological alterations within muscle tissues via inflammatory pathways lead to reduced muscular tone particularly pharyngeal dilator muscle which may result in airway obstruction during sleep. In this regard, several studies showed that weight loss is considered as the first-line treatment for SDB in obese children and adolescents with a positive association between the amount of weight loss and the severity of SDB.<sup>39–41</sup> However, associations of increased BMI (overweight and obesity) with SDB may not be straightforward where confounding factors, such as age, ethnicity, and craniofacial morphology, may modify this relationship.<sup>36</sup>

Childhood obesity has been rising strikingly in Saudi Arabia driven by sedentary life and dietary habits particularly in those with high-socioeconomic standards.<sup>17</sup> Effective prevention programs to combat progression of obesity during childhood is a priority at this stage. Unfortunately, no such prevention or management measures have been published yet in the local literature which means that number of obese children in Saudi Arabia may continue to rise and reach even more worrisome rates than current.

### Limitations of the Study

Sleep screening in a natural environment is an inherent challenge. Our results were based on questionnaires filled out by parents to assess SDB symptoms. In many cases, those are unaware of their children's sleeping patterns which may lead to scoring inaccuracy. For instance, parental reports tend generally to overestimate the sleep duration of their children.<sup>42</sup> However, we used a validated questionnaire previously applied in several epidemiological studies with good correlation. Furthermore, data were collected within a 2 month window, eliminating the potential bias of scoring due to seasonality.

### CONCLUSION

Twenty-three percent of Saudi schoolchildren were at high risk of developing SDB with male predilection as a risk factor. Snoring, sleep apnea, and mouth breathing were prevalent in high-risk SDB children. There is a strong association between increased BMI and SDB. The epidemic spread of obesity among Saudi schoolchildren and its negative impacts merit serious discussion in future health strategies.

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